Editorial

The challenge of hepatic vein reconstruction in surgical oncology

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In the liver surgical oncology, a complete resection of the primary or metastatic liver tumors remains the main objective. If the tumor invades the hepatic vein or the inferior vena cava (IVC) a curative resection becomes challenging. However, recent advances in intraoperative hemodynamic management together with the refinement of the surgical technique acquired by complex liver surgery and transplantation have allowed to perform hepatic vein or vena cava resection for curation with low morbidity and mortality.

There are several approaches to resect and repair hepatic veins and IVC if their resection is required for a complete tumor removal. The type of repair depends on the tumor infiltration scenarios, which may vary from partial involvement of one hepatic vein to complete invasion of all three hepatic veins. In the case of partial involvement, a simple suture, or the placement of a patch to cover the defect and avoid stenosis usually is sufficient. In complex cases a complete hepatic veins resection and repair using an interposition graft is required.

Within the different types of grafts, we differentiate between prostheses, cryopreserved and autologous (1). The latter are generally the most recommended mainly due to their lower risk of infection or thrombosis. Different autologous graft options have been described, such as the gonadal, iliac, femoral, saphenous, umbilical, inferior mesenteric veins, the hepatic or portal veins of the resected liver, the renal or jugular vein (2-8) (*Figure 1*). The drawbacks of this type of graft are related to the possible complications of obtaining them or that the size is not adequate for the type of repair. Terasaki *et al.* have recently described the impact of standardized method of hepatic vein reconstruction with an external iliac vein graft with acceptable surgical outcomes (9). As the authors describe, the external iliac vein is similar in size to the hepatic vein and allows safe long-term anastomosis with only one case of stenosis in their series. The only drawback of these grafts would be the risk of edema of the lower extremity or compromised venous return if they are not obtained properly and the need to make an additional incision. An alternative option would be the use of the left renal vein. The presence of the left gonadal vein allows renal vein resection with a very low probability of renal dysfunction and can be considered as a safe option for the reconstruction of the hepatic veins. Even so, the use of graft types depends on the complexity of the case and the surgeon's experience.

Cryopreserved grafts are also a good alternative since they are procured from a donor and could be in different size and length (10). However, the main drawback is that a tissue bank is not always available, particularly if hepatic vein reconstruction is required an unplanned manner during resection. Finally, artificial vascular grafts (1), although they should be used as a last resort, are used especially for the reconstruction of the IVC due to its large size, or in cases where it is not possible to obtain a graft from other features.

The greatest challenge is the infiltration of all three hepatic veins with or without associated involvement of the IVC. In this situation, the first step is to decide what type of

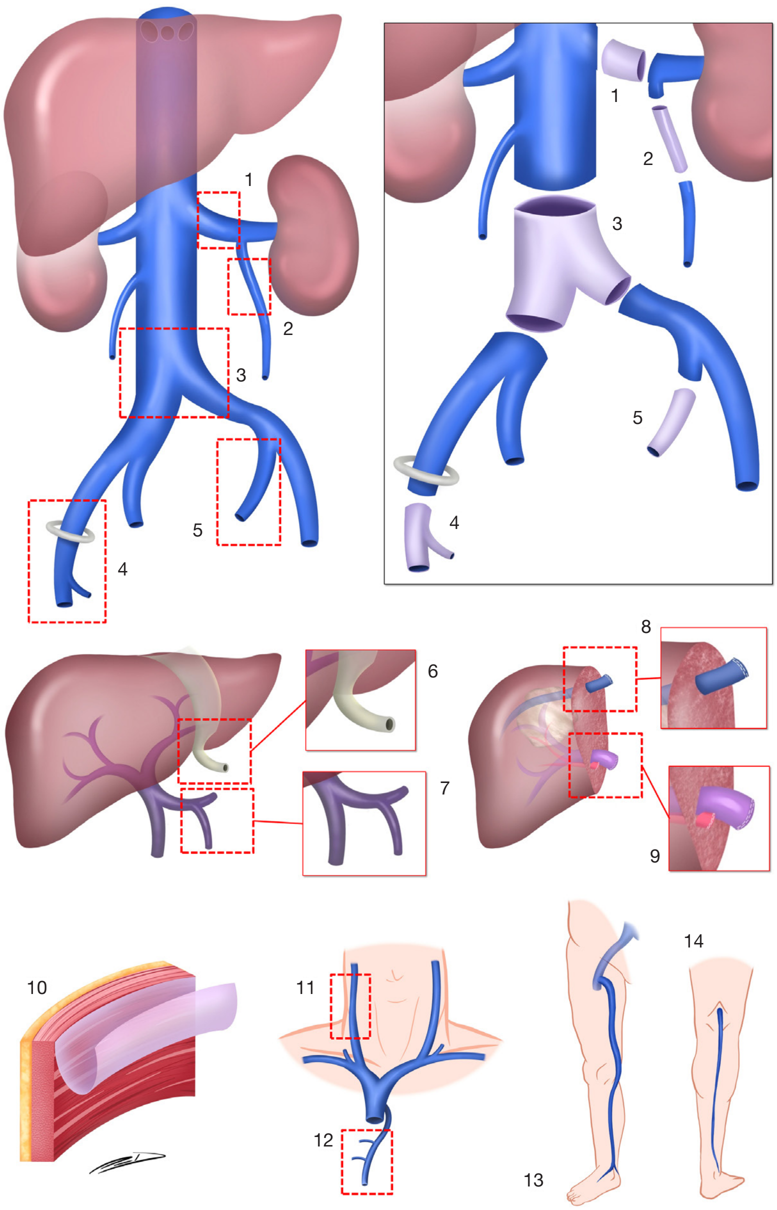

Figure 1 Different autologous or cryopreserved graft options for hepatic vein repair: 1, left renal vein; 2, gonadal/ovarian veins; 3, common iliac vein; 4, external iliac vein; 5, internal iliac vein; 6, round ligament; 7, inferior mesenteric vein; 8–9, hepatic or portal vein from the liver specimen removed; 10, peritoneal patch; 11, internal jugular vein; 12, azygous vein; 13–14, common femoral and saphenous vein.

vascular exclusion and associated hepatic resection approach to perform. Vascular exclusion can be total (portal pedicle, infra and suprahepatic IVC), or partial (occluding the IVC and preserving hepatic flow or occluding portal pedicle and hepatic veins, leaving the IVC free). In case of total vascular occlusion, a veno-venous bypass should be placed, if the patient does not tolerate hemodynamically the clamping test with total vascular exclusion (defined as a decrease in mean arterial pressure >30% and/or a decrease in cardiac index >50% upon vascular exclusion, despite adequate fluid loading). To avoid the clamping test, strict hemodynamic control is essential. In our experience we opt by a supramaximal optimization protocol prior to the clamping test, which is based on a volume replacement to the upper limit of volume overload together with a dobutamine infusion to increase the cardiac output.

The *ex-vivo* liver resection allows the resection and vascular reconstructions under cold storage. However, additional warm ischemia during vascular and bile duct reconstruction and ischemia reperfusion injury are drawbacks. Furthermore, total vascular exclusion is mandatory with the respective disadvantages of long ischemic intervals, especially in those patients suffering from parenchymal disease. For this reason, the increasing number of the authors defend the *in-situ* hypothermic preservation during hepatic vein resection. Dubay *et al.* (11), detailed in their series of nine patients undergoing *in situ* hypothermic perfusion, where mortality rate was 11%, while the Paul Brousse group reported 4.5% mortality and 36% morbidity in their experience with 22 patients with retrohepatic IVC resection (12). Both groups used an *in-situ* liver perfusion to perform the hepatectomy with good results as well as liver function. On the other hand, other authors defend the use of ante situm resection, avoiding *in-situ* hypoperfusion or veno-venous bypass during the ischemic phase of resection (13,14). Recently, Cillo *et al.* describe the first experience in humans of ante situm surgery using hypothermic oxygenated machine perfusion with the advantage of a more efficient and widespread diffusion of cold perfusate and oxygen than cold flushing (15). Our group also avoid bypass and recommend hypothermic *in-situ* perfusion to reduce the risk of liver damage (especially in the case of aggressive preoperative chemotherapy) (8).

Within the alternatives for hepatic vein reconstruction there are some exceptional situations. Reconstruction of the tributary branches of the hepatic veins should be particularly highlighted. In this scenario vascular grafts are needed for the correct drainage of the entire liver, especially from the S5 and S8 territories in right lobe graft without middle hepatic vein. In the event of the presence of a right inferior hepatic vein, it should always be respected, and it has even been described that it could remain as the only drainage route for the patient without the need for repair of the hepatic veins. Another option would be the use of the iliac vein bifurcation to repair the IVC and the left hepatic vein at the same time. An alternative to a case of two stage hepatectomy with a lesion in the future hepatic remnant that encompasses the middle and left hepatic vein, it could be its resection with restoration of the veins with a graft to later perform a right hepatectomy. Finally, the use of a graft could also be useful in the case of a repeat hepatectomy with hepatic vein involvement in a patient with a previous extended right or left hepatectomy.

In conclusion, the reconstruction of the hepatic veins in oncological liver surgery is a technical and hemodynamic challenge. It is necessary to standardize the surgical technique and intraoperative anesthetic management in centers specialized in complex liver surgery to obtain successful results. *In-situ* hypothermic liver perfusion might be preferred over *ex-vivo* liver resection. The less need for total vascular exclusion is also another strong argument for the *in-situ* hypothermic liver perfusion. There is a consensus on prioritizing the use of autologous grafts, when possible, although the type of graft will depend on the size of the defect to be repaired, the patient's conditions, and the preferences of the surgical team.

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